

MODELING OF WATER SEEPAGE INTO AN UNDERGROUND OPENING

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RESEARCH OBJECTIVES

Seepage of liquid water into underground openings such as a waste emplacement drift is a key factor affecting the performance of the potential nuclear-waste repository at Yucca Mountain, Nevada. The prediction of drift seepage relies on capturing the relevant flow processes in an unsaturated fracture network as well as accurately representing the conditions encountered at the drift surface. The objective of this research is to design a modeling strategy for the development, calibration and testing of drift seepage models. The approach is applied to the analysis of liquid-release tests conducted at Yucca Mountain.

APPROACH

Sensitivity analyses show that the heterogeneity, permeability and capillary strength of the fractures determine the amount of water seeping into an underground opening. The general modeling approach therefore consisted of the following steps. A geostatistical analysis of permeability data from air-injection tests was performed, providing measures of the small-scale variability and correlation structure. This information was then used to develop a three-dimensional, heterogeneous drift seepage model. The model was calibrated against seepage-relevant data from liquid-release tests, in which water was injected from boreholes and collected as it seeped into the opening. Calibration by inverse modeling is a critical step in the procedure as it provides effective, model-related, seepage-specific flow parameters on the scale of interest. To test the ability of the model to make seepage predictions, Monte Carlo simulations were performed and compared to data from additional liquid-release tests that were not used during calibration.

ACCOMPLISHMENTS

A high-resolution numerical model was developed (see Figure 1), which captures the relevant physical processes governing seepage into an underground opening excavated from unsaturated fractured rock. It was demonstrated that the estimation of effective flow parameters by conducting and analyzing seepage-relevant experiments is a key step in model development. The calibrated model was able to successfully predict seepage from liquid-release tests with different flow rates. Furthermore, it was demonstrated that the continuum approach can be appropriate for predicting a specific behavior of a complex discrete fracture network system.

SIGNIFICANCE OF FINDINGS

The approach developed in this research provides the basis for extensive seepage predictions under a variety of conditions. The modeling results support the concept of a seepage threshold, i.e., a percolation flux below which no seepage occurs. The existence of a seepage threshold and the fact that seepage rates are likely to be smaller than percolation rates as a result of the capillary barrier effect is a result of great significance for the performance of a potential nuclear waste repository at Yucca Mountain.

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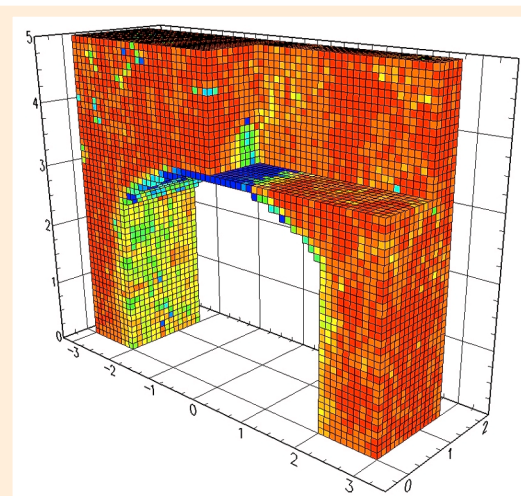


Figure 1. Saturation distribution during simulation of liquid-release test performed to calibrate three-dimensional, heterogeneous drift seepage model.

RELATED PUBLICATIONS

Finsterle, S., Using the continuum approach to model unsaturated flow in fractured rock, accepted for publication in Water Resour. Res., 2000.

ACKNOWLEDGEMENTS

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